

AXrEM Industry Position Statement

The Relationship between Investments in Advanced Imaging Technology, Better Disease Prevention and a Leaner, More Cost Effective NHS

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AXrEM

Executive Summary

The NHS is facing an unprecedented challenge to deliver more effective treatments to more people at a lower cost and at the same time better survival rates for priority disease areas, including heart disease, stroke and cancer. There is an expectation that up to £3.5 billion in annual savings could be delivered by improving productivity, based on best in class (NHS 2010–2015: from good to great, Department of Health 2009). It is therefore imperative for the NHS to focus on quality, innovation, productivity and prevention and this imperative is embodied in the NHS QIPP (Quality, Innovation, Productivity and Prevention) Challenge in England.

There is always a risk in an adverse economic climate that discretionary spending will be restricted and that the procurement of technologies, in particular expensive technologies, will be restricted or delayed. However, the core values of the NHS are the same and any efficiency gains to pay for future growth would need to come from initiatives that do not have any adverse impact on front line service. This creates a requirement for greater sophistication in measuring and managing healthcare costs.

Advanced imaging technologies provide a case example. Between 2000/2001 and 2008/9 there was a 173% growth in Magnetic Resonance Imaging (MRI) scans and 125% growth in CT scans (Department of Health Episode Statistics). However, whilst the level of investment in these technologies has been transparent, measures of the impact on disease prevention, disease outcomes and overall healthcare expenditure have been sparse.

The available evidence points to a substantial contribution of advanced imaging technologies in delivering financial balance and key operating targets. Studies from the US indicate that expenditure on imaging is a predictor of reduced length of stay and correlates with larger increases in life expectancy and a three-fold level of saving for every unit of currency invested (Beinfeld and Gazell 2005, and Lichtenburg 2009). Savings on downstream healthcare costs can be achieved by reducing hospitalisation rates (Schousboe et al, 2005); reducing avoidable or inappropriate

interventions (May et al, 2009); enabling less invasive and less risky procedures and avoiding costly disease outcomes.

It is essential for the NHS to develop more advanced ways of measuring return on sizeable capital investment that include the impact on downstream costs, since these have rarely been considered. This is an endeavour that would lend itself to increased partnership between the NHS and healthcare industries.

This paper identifies numerous patient pathways that could be transformed with further investment in advanced imaging technologies, at the same time contributing to reducing the overall cost of care. There are many specific technologies that have reasonable levels of evidence to support this. Just a few of these outlined in this report are:

- CT screening to identify lung cancer earlier (page 13, The International Early Lung Cancer Action Program investigators, 2006)
- The existing nationwide deployment of digital mammography (page 21, Skaane 2004) with the addition of contrast-enhanced MRI (page 14, Griebisch et al, 2006) for breast cancer screening.
- The use of CT Colonography in the improvements in the early detection, prevention and treatment of cancer (page 15, NICE CG:41 2006, Pickhardt 2007).
- Improvements in the early detection, prevention and treatment of coronary artery disease using CT angiography (page 17, May et al. 2009, Chang 2008).

- Cost-effective stroke prevention and management using CT perfusion (page 19, CEP 2008) and indeed simply the provision of an MRI or CT scan for transient ischaemic attacks within one week of the event (page 20, NICE 2008).

In general, future developments in imaging technology will support more accurate diagnosis and faster imaging, which will drive greater productivity, better treatment outcomes and a reduction in the number of necessary downstream tests and interventions. There is considerable potential for benefit from cardiac MRI (page 23, Chan 2006) and interventional radiology (page 24, National Imaging Board, March 2010) as well as many other emerging technologies (page 25). Therefore, this will create the incentive for continued investment and growth.

It is argued that prudent investment in developments will result in faster, more accurate, safer and less invasive tests. It will be central to QIPP and the delivery of the NHS five year strategy, **“NHS 2010-2015 from Good to Great”**. AXrEM’s members are keen to contribute to solutions to this NHS leadership challenge, leveraging improvements in imaging technologies to drive leaner and more effective clinical pathways.

This position paper has been prepared for AXrEM by ATP Consulting Ltd on behalf of its members and is intended to inform ministers, healthcare policy makers, commissioners and providers.

Commentary

“ This paper provides a useful summary of the importance of diagnostic imaging in maintaining health and combating disease in the population, which are key aims of the British Institute of Radiology. It demonstrates the many ways in which diagnostic imaging technology can be of benefit to the community. Adoption of modern imaging technology into the 21st century healthcare system in a climate of economic restraint is a challenge and this paper creates useful and important links with the quality of healthcare. ”

Stephen G Davies
Vice President British Institute of Radiology

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1: Introduction

The NHS five year strategy, “**NHS 2010-2015 from Good to Great**”, states that priority is to be given to interventions that prevent the early onset of diseases, with the aims of reducing demand for acute services in all disease areas and reducing health inequalities. In particular, it states that the NHS needs to drive out variation in cancer, stroke and heart disease.

The enabling objectives include:

- reducing the number of acute beds;
- reducing unit costs and variations; and
- focusing on early intervention.

In parallel with these quality improvements, a requirement is laid out in the NHS strategy to deliver efficiency savings over the three-year period from April 2011 of £15-20 billion, i.e. 7% per annum, as a means of increasing real terms resources available for patient care year by year. There is also an interim challenge to deliver £10 billion in efficiency savings by 2012/13, including quality improvements. In contribution to this saving, there is an expectation that enabling all hospitals to meet the levels of staff productivity currently achieved by the best could annual deliver savings of up to £3.5 billion

The average allocation to PCTs in 2010/11 has remained unchanged and there is an expectation that funding for growth required for this year should come from savings made by PCTs as a result of lower tariff prices. For the years 2011/12 and 2012/13, allocations will be in line with inflation and capital expenditure will be reduced. Between 2010 and 2013, there is to be no uplift in national tariff prices and after 2010/11 national tariffs will represent the maximum price payable by a commissioner. This means that PCTs will be able to negotiate lower tariffs and NHS Trusts will be pressured to compete on price as well as quality.

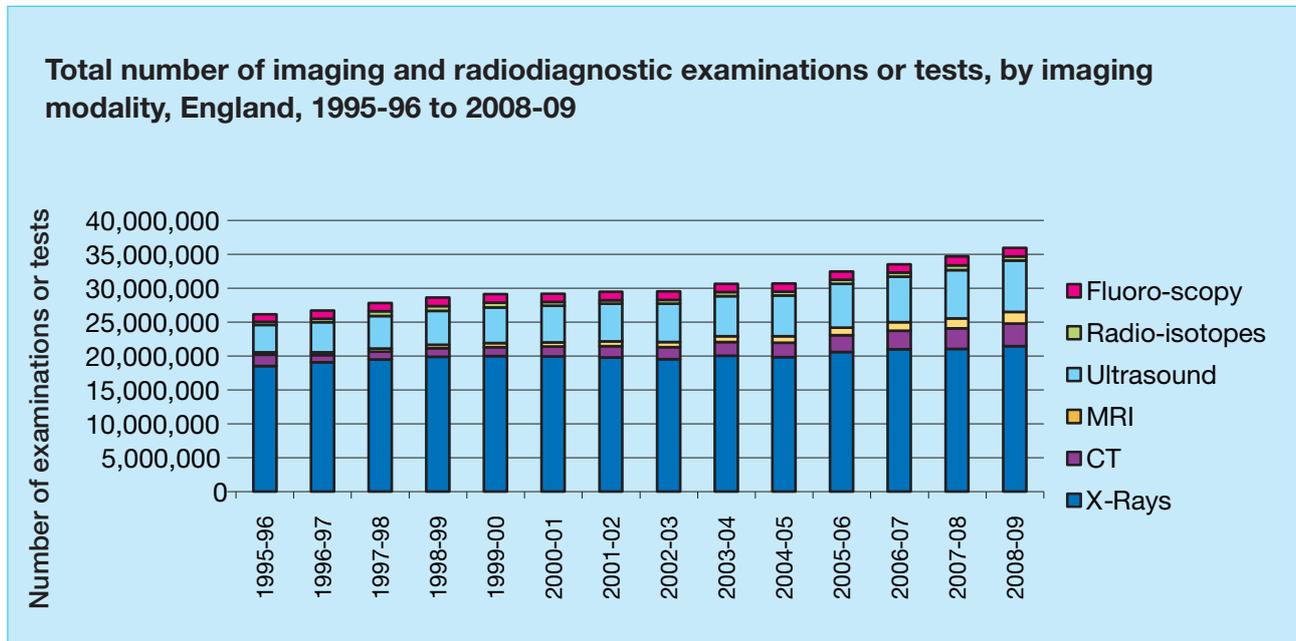
A number of enablers and levers have been also been built into the tariff system in 2010/11 (Payment by Results Guidance 2010/11), including:

- Best practice tariffs for cataracts, cholecystectomy, fragility hip fracture and stroke in 2010/11. The intention is to reduce the variation in quality between providers.
- During 2010/11 any emergency activity above a contracted baseline will only be paid for at a rate of 30 per cent of the relevant tariff, to incentivise leaner and more effective preventative, diagnostic and treatment pathways. It is proposed that the savings will be invested in services that reduce emergency admissions.

To drive the level of changes required to quality and efficiency, the Department of Health has introduced the Quality Innovation Productivity and Prevention Challenge (QIPP). This initiative will be supported by the NHS Institute and staff will be engaged at all levels of the NHS to eliminate error and wasteful practices and create leaner, more effective care pathways www.evidence.nhs.uk/qualityandproductivity. As an incentive, under the CQUIN scheme, 1.5% of NHS Trust income will be contingent on delivery of quality targets relating to disease prevention, service access and quality. Some of these targets are fixed at the same performance level nationally (Tier 1 Vital Signs), some are defined nationally with performance target levels open to local negotiation (Tier 2 Vital Signs) and the remainder are fully subject to local negotiation, depending on local priorities (Tier 3 Vital Signs). (NHS Operating Framework 2010/11).

In this tougher economic environment, the contribution of technological advances and increased adoption on rising healthcare costs will be a subject of increasing concern to NHS Trusts and commissioners. The utilisation of imaging services has increased rapidly in recent years, as the following chart shows.

Chart 1: Growth in Number of Imaging Tests across England



Department of Health

http://www.dh.gov.uk/en/Publicationsandstatistics/Statistics/Perfomancedataandstatistics/HospitalActivityStatistics/DH_077487

Department of Health Hospital Activity Statistics 077487

Between 2000/2001 and 2008/9 there was an 8% growth in the number of X-Rays; 125% in Computed Tomography (CT) scans; 173% in Magnetic Resonance Imaging (MRI) scans and 40% in ultrasound. There is no doubt that advanced imaging equipment can be costly to set up and run and in the current economic climate the rate of increase in expenditure will need to be scrutinised to determine whether increased investment has yielded added value or has been a major contributor to the financial problem.

This position paper argues that investment in advanced imaging technologies reduces overall healthcare expenditure and should therefore be embraced as part of the QIPP solution for the NHS rather than treated as part of the problem.

It explores the contribution that these technologies can make to the wider priorities and targets of the NHS. In recognition of the specific contribution of advanced imaging technologies, the 18 week pathway team initiated an imaging work programme in 2008/09.

The programme was designed to enable and support the NHS to modernise and reform diagnostic imaging services through:

- The development of materials to support new models of service provision, particularly in ultrasound and nuclear medicine
- Ongoing development of a web based tool to support commissioners to commission world class imaging services
- Specialised and specific support via NHS Improvement for Trusts struggling to comply with 18 Weeks
- Ongoing work to identify and assess new technologies in imaging to improve patient outcomes and maintain safe use of radiation
- Ongoing work to ensure that unbundling of the payment by results tariff is accurate and guidance/coding are appropriate for imaging services
- Ongoing support for the development of patient pathways and clinical best practice based on evidence

- To develop guidance/support on how to implement the Cancer Reform Strategy in relation to imaging

Although performance management of the 18 weeks waiting times target by the Department of Health has now ceased (Revision to the Operating Framework for the NHS in England 2010/1) referral to treatment data will continue to be published and monitored.

In addition, there are a number of NHS organisations with responsibility to enable greater access to technologies that benefit patients and the public, including:

- Medicines and Healthcare Regulatory Authority
www.mhra.gov.uk/index.htm
- National Institute for Clinical Excellence
www.nice.org.uk
- Centre for Evidence Based Purchasing
www.pasa.nhs.uk/PASAWeb/NHSprocurement/CEP
- National Innovation Centre
www.nic.nhs.uk/about/pages/introduction.aspx
- National institute for Health Research – Health technology Assessments
www.ncchta.org/index.shtml
- NHS Technology Adoption Hub
www.technologyadoptionhub.nhs.uk

All these indicate awareness that delivering the NHS 2010-2015 modernisation agenda, whilst at the same time delivering substantial savings; will depend on prudent investment in advanced technologies. The NHS Plan also states that PCTs should make 2 per cent of their budget available to be spent on ‘non-recurrent’ items to support service transformation. All PCTs will have to meet this requirement (as a minimum) by 2013/14. This reflects the commitment to non recurrent investment in capital assets and pump priming to support the modernisation agenda. These initiatives collectively suggest there is a good level of awareness at policy and strategy level of the added value of advanced imaging technologies.

However, since payment by results bundles the payment for advanced imaging technologies into the overall payment for a complex spell of care, the impact of investment in advanced imaging technologies (AITS) may not be transparent at hospital level. In addition, evidence of cost effectiveness for these types of technologies is growing but sparse. There remains a risk, therefore, that commissioners and NHS Trusts will decelerate investment in advanced imaging technologies and fail to realise that this is likely to increase the overall cost of healthcare and put at risk delivery of important NHS targets.

AXrEM’s members are keen to contribute to solutions to this NHS leadership challenge, leveraging improvements in imaging technologies to drive leaner and more effective clinical pathways.

This position paper highlights the opportunities for the NHS to reduce costs, transform patient care and deliver tangible improvements in operational performance through investment in imaging.

2: The Contribution of Advanced Imaging Technologies to the Delivery of NHS Imperatives

This section explores the contribution that advanced imaging technologies have made to the following key NHS imperatives:

- Financial balance and key operating targets
- Cancer service modernisation
- Improvements in the early detection, prevention and treatment of cardiovascular disease
- Stroke prevention and management

2.1: Impact of Advanced Imaging Technologies on Healthcare Expenditure

Financial balance for PCT's is a Tier 1 Vital Sign in the NHS Operating Framework for 2010/11.

Recent studies in the US suggest that advanced imaging technologies deliver healthcare benefits without increasing the overall burden of healthcare costs. This has led to calls to move from separate fee for service diagnostics to fixed all inclusive payments for hospitalisation, to make the association between effective use of advanced imaging technologies and overall healthcare costs more transparent (Hackbarth et al, 2008). For the same reason, NHS diagnostic imaging tariffs have been rebundled with the outpatient attendance tariffs in England in 2010/2011, except for direct access.

In 2005, Beinfeld and Gazell published a retrospective study to determine how the utilisation of CT and MRI scans influenced the cost of inpatient hospital care at a General Hospital in the US and concluded that diagnostic imaging costs were unlikely to be a dominant driver for hospital costs and, indeed, every \$1 spent on imaging correlated to approximately \$3 in total savings.

A study by Lichtenburg for the National Bureau of Economic Research (2009) examined the effect of the quality of medical care, behavioural risk factors, and other variables on life expectancy and medical expenditure using longitudinal state level data. Three different measures of the quality of medical care were examined, including the average quality of diagnostic procedures, defined as the fraction of procedures that are advanced. States with larger increases in the

quality of diagnostic procedures had larger increases in life expectancy but did not have larger increases in per capita expenditure. The author speculated that this may be because newer technologies may reduce the need for costly additional treatments even though the newer diagnostic procedures are more costly.

Diagnostic Imaging can provide cost savings in several ways, for example, by:

- **Reducing downstream treatment costs**
- **Reducing hospitalisation rates** e.g. Bone densitometry can identify bone loss early enough to significantly reduce fracture risk. A 2005 study published in *Osteoporosis International* estimated that bone mineral density scanning of an additional one million women in 2001, followed by appropriate osteoporosis therapy, would have averted 35,000 fractures and generated \$78 million in savings by 2003 (Schousboe et al). In addition, computerised tomography (CT) reduced unnecessary hospital admission, which combined with a reduction in unnecessary appendectomies (see below) generated net cost savings of \$447 per patient (Rao et al, 1998).
- **Reducing avoidable or inappropriate interventions** e.g. Computerised tomography (CT), for example significantly reduced unnecessary

appendectomies and when combined with the reduction in unnecessary hospital admission, the net cost savings were \$447 per patient (Rao et al, 1998). CT angiography also generated cost savings in the triage chest pain patients in the emergency room (May et al, 2009 and ROMICAT trial, Hoffman et al, 2009) by decreasing mean length of stay and associated hospital charges, and avoiding unnecessary cardiac catheterisations. Chang's retrospective study (n=643) comparing four strategies to evaluate patients with low risk chest pain found that CT angiography carried out in the emergency room was just as safe and effective as alternate strategies but lower in cost, allowed discharge for the majority of patients and was associated with a shorter length of stay.

- **Enabling minimally invasive procedures that reduce both operating room time, length of stay and recovery time** i.e. Ultrasound (US), magnetic resonance imaging (MRI), along with positron emission tomography (PET) and single-photon emission computed tomography (SPECT) — which can be used in combination with CT— have paved the way for minimally invasive therapeutic procedures. These have reduced hospital length of stay and admission costs considerably.
- **Replacing of more invasive, higher risk diagnostic methods** i.e. Ultrasound (US), magnetic resonance imaging (MRI), along with positron emission tomography (PET) and single-photon emission computed tomography (SPECT) — which can be used in combination with CT— have paved the way for minimally invasive diagnostic procedures. These technologies not only provide more complete assessments to guide initial treatment decisions, but can help physicians determine how well certain therapies are working, and provide more accurate, less invasive monitoring for disease recurrence.
- **Avoiding costly disease outcomes** e.g. NICE clinical guideline 88 recommends MRI for non specific back pain within the context of a referral for spinal fusion and when a diagnosis of spinal malignancy, infection, fracture, cauda equina syndrome, ankylosing spondylitis or another inflammatory disorder are suspected. Appropriate management of low back pain can minimize the economic impact of long term disability caused by increased healthcare visits, prescriptions and lost productivity.

2.2: Impact of advanced imaging technologies on NHS operational performance targets

In addition to reducing error and waste across care pathways, with an overall positive impact on cost, advanced imaging technologies have the potential to contribute to NHS operational imperatives in the following ways:

Table 1: General Contribution of Advanced Imaging Technologies to NHS Priorities and Performance Targets

NHS Priority/Target	NHS Operating Framework 2010/11	Potential Contribution of Advanced Imaging Technologies
A four-hour maximum wait in A&E from arrival to admission, transfer or discharge (95% threshold)	Existing priorities	Delivery of rapid diagnostic information to avoid unnecessary admission and guide appropriate and effective treatment
Number of emergency bed days per head of weighted population	Tier 2 Vital Sign	Delivery of rapid diagnostic information to avoid unnecessary admission and guide appropriate and effective treatment, minimising hospital stay
All-age, all-cause mortality rate per 100,000 population	Tier 2 Vital Sign	Accurate and fast diagnosis, avoidance of disease progression and appropriate effective treatment will reduce avoidable deaths
Healthy life expectancy at age 65	Tier 2 Vital Sign	Accurate and fast diagnosis, avoidance of disease progression and appropriate effective treatment will prolong life and improve quality of life
Proportion of people where health affects the amount/type of work they can do	Tier 2 Vital Sign	Avoiding disease progression and supporting minimally invasive interventions will result in faster return to full functioning
Emergency admissions and length of stay	Tier 2 Vital Sign	Delivery of rapid diagnostic information to avoid unnecessary admission and guide appropriate and effective treatment, minimising hospital stay

NHS Priority/Target	NHS Operating Framework 2010/11	Potential Contribution of Advanced Imaging Technologies
Emergency readmissions	Tier 2 Vital Sign	Accurate diagnosis on the first admission will result in appropriate treatment and reduce the risk of disease reoccurrence or progression resulting in readmission
Admissions from A&E and length of stay	Tier 2 Vital Sign	Delivery of rapid diagnostic information to avoid unnecessary admission and guide appropriate and effective treatment, minimising hospital stay
Mortality rate from causes considered amenable to healthcare	Tier 3 Vital Sign (Example)	Accurate and fast diagnosis, avoidance of disease progression and appropriate effective treatment will reduce avoidable deaths
Fractured neck of femur operated on within 36 hours	Tier 3 Vital Sign (Example) Best Practice Tariff	Faster diagnosis and preoperative work up

2.3: Impact of advanced imaging technologies on cancer service modernisation

Although advanced medical imaging has improved diagnosis and treatment for acute and chronic conditions ranging from abdominal pain and Alzheimer’s disease to stroke and other cardiovascular diseases, cancer treatment is the clinical area that has benefited most from these technologies.

However, England still has poorer survival rates for many cancers than many other similar countries – there is a belief that this is largely due to late diagnosis, and up to 10,000 lives a year could potentially be saved if patients with cancer were diagnosed earlier (NHS 2010–2015: from good to great, Department of Health 2009).

In 2006, 293,601 people were diagnosed with cancer in the UK (Cancer Research UK). Only 42% of these are from urgent GP referral and another 5% from screening. The rest are diagnosed opportunistically. This suggests there is significant potential to diagnose cancers earlier by, amongst other things, making sure that advanced imaging technologies are faster, support higher throughput, and become safer and less invasive, increasing patient acceptance and compliance. This is particularly important since cancer is a major contributor to death in the UK i.e. 27% of all deaths in 2008 (Cancer Research UK). Early identification and treatment improves survival rates for most cancers.

There are a number of important NHS targets relating to cancer services in the NHS Operating Framework for 2010/11:

Relating to Tier 1 Vital Signs:

- A two-week maximum wait from urgent GP referral to first outpatient appointment for all urgent suspected cancer referrals.
- A maximum wait of one month from diagnosis to treatment for all cancers.
- A maximum wait of two months from urgent referral to treatment of all cancers.

Relating to Tier 2 Vital Signs:

- <75 cancer mortality rate

Early detection of cancer improves overall survival for the three biggest cancer killers. The accessibility and accuracy of diagnostic imaging is pivotal to timely and effective diagnostic work up.

It is an NHS priority to drive out variation in cancer diagnostic and treatment pathways and ultimately survival. In recognition, The Department of Health and Cancer UK have teamed up to create an initiative to identify and remove some of the barriers to early access to diagnostic services e.g. patient awareness, primary care delays etc. (NAEDI – Detecting Cancers Earlier – the National Awareness and Early Diagnosis Initiative). In this paper, we explore the contribution of advanced imaging technologies to improvements in early detection and care for the three biggest whole population based cancer killers: Lung; breast and colorectal.

2.3.1 LUNG

Lung cancer accounts for 13.29% of diagnosed cancers per annum (Cancer Research UK 2006) and is the second most common. It is the leading cause of cancer deaths i.e. 22% of all cancer deaths.

In 2006, The International Lung Cancer Action Program collaborative study screened 31,567 asymptomatic persons at risk from lung cancer using low dose CT. Repeated screenings were carried out 7-18 months after the initial screening. Screening resulted in a diagnosis of lung cancer in 484 participants (1.53%). Of these 85% had Stage I lung cancer and 73% of these underwent surgical resection within one months of diagnosis. The survival rate for patients undergoing surgery was 92%.

The authors state that, in a population at risk for lung cancer, such screening could prevent some 80% of deaths from lung cancer. By comparison, in the United States at present, annually approximately 173,000 persons are diagnosed with lung cancer and 164,000 deaths are attributed to this disease (American Cancer Society 2005) so that approximately 95% of those who are diagnosed with lung cancer die from it.

The authors concluded that annual spiral CT screening can detect lung cancer that is curable and that CT screening is highly cost effective, since the cost of surgery for treating Stage I lung cancer is less than half the cost of late stage treatment and survival profiles are very different.

2.3.2 BREAST

Breast cancer accounts for 15.61% of diagnosed cancers per annum (Cancer Research UK 2006) and is the most common. It is the third most common cause of cancer deaths accounting for 8% of all cancer deaths.

There are a number of important NHS targets relating to cancer services in the NHS Operating Framework for 2010/11:

Relating to Tier 1 Vital Signs:

- Proportion of patients with breast symptoms referred to a specialist who are seen within two weeks of referral All patients by December 2009
- Proportion of women aged 47–49 and 71–73 offered screening for breast cancer NHS Breast Cancer Screening Programme will be extended to all women aged 47–73 by 2012

Mammography, hailed in the *Journal of the American Medical Association* as “one of the most important recent achievements in cancer control,” has been associated with a 24% decrease in the death rate from breast cancer (even after taking patient age into account) from 1989-2003 (Kolata 2002)

Women with a known family history of breast and/or ovarian cancer or mutations in *BRCA1* and *BRCA2* have a higher lifetime risk of breast cancer than the general population with tumours often occurring at a young age and more often being of a high grade. Several prevention strategies for these women have been identified including bilateral prophylactic mastectomy, chemoprevention and screening with annual mammography (Lieberman, 2004; McIntosh *et al*, 2004).

Current guidance in the UK recommends that all women aged 40–49 years with a moderate risk (lifetime risk >17%) should be offered annual mammographic

surveillance (McIntosh *et al*, 2004). There has been, however, some concern about the poor sensitivity of mammography due to mammographically dense breast tissue in younger, premenopausal women and tumours resulting from gene mutations may potentially have a more aggressive phenotype (Liberman, 2004).

Over the last decade, magnetic resonance imaging (MRI) has emerged as a potential investigation for the detection and diagnosis of breast cancer and, unlike mammography, it is not affected by breast density. This has prompted a number of investigators to evaluate the feasibility of MRI in a screening context.

One of these studies is the UK national study for magnetic resonance imaging screening of women at high familial risk of breast cancer (MARIBS) that was set up to compare the sensitivity and specificity of contrast-enhanced magnetic resonance imaging (CE MRI) with two-view mammography (Griebsch *et al*, 2006). This study and other prospective screening studies (Kriege *et al*, 2004; Warner *et al*, 2004; Kuhl *et al*, 2005) consistently showed that CE-MRI is significantly more sensitive than X-ray mammography (XRM) in a high-risk population.

The findings of the analysis suggest that the addition of CE MRI to a surveillance programme for women at high familial risk for breast cancer might be a cost-effective health care intervention (Griebsch *et al*, 2006). This is particularly true for the *BRCA1* and *BRCA2* groups, which suggested that the incremental cost per detected cancer with CE MRI (combined with mammography or with CE MRI alone) is £11 800 and £15 300 respectively when compared to mammography alone. Anticipated technical improvements in MRI technology together with an optimised use in a routine screening setting suggest potentially lower cost for a CE MRI test than the amount calculated in this study setting.

For patients with a high risk of breast cancer between 20 and 49, including women who have one of the faulty high risk genes, NICE now recommend the use of MRI for breast cancer surveillance (CG 41: October 2006). This recommendation is broadly consistent with the guidelines from the European Society for Breast Imaging (2008) and the American Cancer Society Guidelines (2007).

2.3.3 COLORECTAL

Colorectal cancer accounts for 12.78% of diagnosed cancers per annum (Cancer Research UK 2006) and is the third most common. It is also the second biggest cancer killer in the UK, accounting for 10% of all cancer deaths. The NHS Bowel Screening Programme began in England in 2006 and in Scotland in 2007. Cancer Research UK state there could be up to 20,000 fewer deaths from bowel cancer over the next 20 years if just 60% of those eligible took up the invitation for bowel screening.

In a US study, the long-term healthcare cost of colorectal cancer care depending on the stage at diagnosis is estimated to be between \$46 and \$71 million*, representing a high cost to the healthcare system.

*Derived from Centers for Medicare and Medicaid Services and published data. Costs were updated to 2003 dollars using the medical services component of the consumer price index. Indirect costs were not included. Long-term cost was defined as cancer-related cost from diagnosis until death or 15-25 years following diagnosis. Source: Song *et al* (2004)

There are a number of important NHS targets relating to cancer services in the NHS Operating Framework for 2010/11:

Relating to Tier 1 Vital Signs:

Proportion of men and women aged 70–75 taking part in bowel screening programme NHS Bowel Cancer Screening Programme will be extended from this year to invite men and women aged 70–75 to take part.

The NHS target to expand bowel cancer screening will put additional strain on NHS endoscopy capacity. Additional investment will be needed in appropriate technologies to meet the increase in demand. Colonoscopy (OC) is the current standard for bowel cancer screening and symptomatic bowel diagnosis. Colonoscopy provides a view of the inside of the bowel. Timely colonoscopy can reveal polyps and

certain types of polyps, called adenomatous polyps, may later develop into colon cancer. Therefore removal of polyps is useful in preventing the onset of cancer. Even if cancer is detected during a colonoscopy, patients with earlier stages of disease have better chances of survival.

Although colonoscopy is considered to be the gold standard imaging system for the colon, in many cases computed tomographic colonography (CTC) has been found to be as effective and also has other advantages. CTC is a virtual colonoscopy that takes abdominal computerised scans of the colon for the detection of colorectal polyps and masses. These computer generated images of the colon simulate a colonoscopy but are non-invasive.

From a study, Primary CT Colonography and Optical Colonoscopy screening strategies resulted in similar detection rates for advanced neoplasia, although the numbers of polypectomies and complications were considerably smaller in the CTC group. The author concluded that these findings support the use of CTC as a primary screening test before therapeutic OC. (Kim et al 2007).

Furthermore, CTC and OC screening methods resulted in similar detection rates for advanced neoplasias within the same general population. This finding is important because advanced neoplasms represent the primary target of colorectal screening and cancer prevention. The marked decrease in the use of OC and total rates of polypectomies in the CTC group suggests that this technique could be a safe, clinically effective, and cost effective filter for therapeutic OC. Also, by combining primary CTC and primary OC screening efforts, with the choice between tests driven by patient preference, the overall screening compliance for total colonic examination could substantially increased. (Kim et al 2007).

The first year's experience of the first CTC program covered by third party payers introduced in 2004 in the States was reported by Pickhardt et al (2007). 1,110 consecutive adults underwent screening and results were given within 2 hours. Patients with large polyps were referred the same day for treatment and patients with medium sized lesions had the option of therapeutic colonoscopy OR CTC surveillance. 60%

chose CTC surveillance. The demand from primary care physicians increased over the study period indicating that CTC screening can increase compliance without increasing the overall demand for colonoscopy. The estimated cost of CTC was \$478 compared to \$690 for a diagnostic colonoscopy and \$1139 for a therapeutic colonoscopy. This took into account the cost of expected complications. In a recent cost effectiveness study by Pickhardt et al (2007), it was concluded that compared with colonoscopy screening, the annual program of CTC with none reporting of small lesions costs nearly \$1 billion less for an estimated 4% drop in relative colorectal cancer prevention. They proposed that the removal of small lesions appears to carry an unjustified overall burden of costs and complications in relation to the minimal gain in clinical efficacy. The results of this study differed from previous studies because consensus guidelines recommend 6mm as the size of polyp for reporting at CTC. The guidelines were followed for this study whereas all polyps were reported in previous studies. In addition, CTC continues to evolve and improve.

There are two developments in progress that will increase the efficacy of CTC:

- Computer assisted diagnosis (CAD) – computer aided detection speeds up interpretation, reduced inter reader variability and locates polyps more accurately (Halligan et al). It appears to increase sensitivity to that of colonoscopy in an asymptomatic screening population for adenomas 8mm or larger (Summers et al)
- “Prepless” VCAR CTC – bowel preparation is one of the major barriers for patients in taking up colonoscopy or CTC screening. With this type of CTC bowel preparation is replaced by fecal tagging using barium suspension or iodinated contrast agent in combination with low residue diet. Studies to date suggest this method yields comparable accuracy to standard CTC and colonoscopy but that patients prefer it (Callstrom et al, Lefere et al, Zalis et al, Iannacone et al and Johnson et al)

This is therefore an evolving screening technology which promises to deliver a higher patient acceptance, diagnostic accuracy, and screening effectiveness, thereby decreasing mortality rates due to colorectal cancer.

2.4: Impact of advanced imaging technologies on coronary artery disease

It remains a priority for the NHS to reduce cardiovascular disease mortality rates in people less than 75 years of age (Tier 2 Vital Sign).

Chest pain and symptoms of occlusive stroke or transient ischemic attack are common presentations in the NHS and indicative of coronary artery disease.

2.4.1 ACUTE CHEST PAIN

Acute chest pain and Coronary Artery Disease is the leading cause of morbidity and mortality in the UK. There is a prevalence of angina in over 2 million people and in 2001 statistics showed there were 120 000 deaths from Coronary Artery Disease, with over 38% are under the age of 75. (Hernandez 2007 and Coronary Heart Disease Statistics. [2002] BHF).

There are a number of important NHS targets relating to the diagnosis and management of chest pain in the NHS Operating Framework for 2010/11:

Relating to Tier 1 Vital Signs:

- A maximum two-week wait standard for Rapid Access Chest Pain Clinics

National Service Framework for Coronary Heart Disease Indicators:

N.B. Emphasised the importance of early diagnosis.

- Rate of cardiovascular events in people with a prior diagnosis of CHD, PVD, TIA or occlusive stroke.
- Reference costs for chest pain
- Reference costs for acute atherosclerosis
- Reference costs for angina
- Referral to a specialist within 2 weeks and revascularisation within 3 months, if there is a decision to operate

NHS Heart Improvement Programme – an NHS Improvement Programme closely aligned with QIPP.

There are a number of important NHS targets relating to the diagnosis and management of chest pain in the NHS Operating Framework for 2010/11:

NHS 18 weeks

The NHS 18 weeks programme had a focus on cardiac diagnostics. It encouraged “lean thinking” and advised commissioners to keep on the horizon for future technology developments i.e. non invasive tests, faster tests, more portable technology, better outcomes, and one stop clinics etc.

The initiative provided support to cardiac networks and commissioners of cardiac services and delivered a number of tools including:

- **Transforming Cardiac Diagnostics to Deliver 18 weeks – A Good Practice Guide (2007)**
- **18 week commissioning pathway for chest pain**

A&E chest pain pathways employ a standard of care diagnostic work up to exclude myocardial infarction, which include serial ECGs and cardiac enzymes followed by rest and/or stress imaging studies. These are time consuming, expensive and not always definitive (Goldstein et al, 2009).

The National Imaging Board argues that it may be possible to reduce the requirement for coronary angiography in those patients who have normal coronary vessels or mild / moderate coronary disease with no evidence of reversible ischemia because they can safely be managed medically in the first instance, with coronary angiography being used if their symptoms cannot be controlled.

According to the 2008-9 Hospital Episode Statistics data for England, the figures for diagnostic coronary angiography and revascularisation on stable patients admitted from a waiting list were as follows:

Table 2: NHS Hospital Episode Statistics 2008-9

Procedure	Procedure Codes	
Coronary angiography	K63.1 – K63.9	119,954
Percutaneous coronary intervention (PCI)	K49.1 – K50.9 and K75.1 – K75.9	30,727
Coronary artery bypass graft (CABG)	K40.1-K45.9	18,232

These data suggest approximately 71,000 stable patients underwent diagnostic coronary angiography but did not proceed to revascularisation via PCI or CABG in England. This indicates the potential to use functional imaging e.g. CT coronary angiography (CTA) in the diagnostic work up to identify patients suitable for more invasive procedures and rule out unnecessary procedures. It is likely that a high proportion of these patients were referred for diagnostic coronary angiography without prior functional imaging. In some cardiac networks, it has been acknowledged that patients with suspected stable angina are referred for coronary angiography rather than functional imaging simply because of ease of access (i.e. shorter waiting times for angiography than for non-invasive functional imaging).

May et al (2009) conducted a standard of care evaluation and found that length of stay and hospital costs were significantly less for patients with CTA added to the standard of care workup than for the standard of care workup alone, due to reduced hospitalisation rates and avoidance of unnecessary catheterisations. In addition, Chang et al (2008) conducted a retrospective comparison of four strategies for evaluation of patients with chest pain. Their results indicated that immediate CTA in the emergency room is safe and identifies as many patients with CAD, but has the lowest cost, lowest length of stay and allows the majority of patients to be discharged. They recommend larger studies to confirm safety.

A pilot study in the Greater Manchester and Cheshire Cardiovascular and Stroke Network is currently examining this issue. The redesigned pathway will allow for an extra 10,000 patients a year having functional imaging instead of stress ECG. Since 16% of patients who were previously (NICE Guidance 73) false negatives will be diagnosed as having angina this has the potential to lead to a 4% annual reduction of death and 20% absolute reduction in angina. The Quality Adjusted Life Year (QALY) is estimated to be 0.75 for each full year saved, where the QALY is a measure created to combine the quantity and quality of life. The basic idea of a QALY is straightforward. It takes one year of perfect health-life expectancy to be worth 1, but regards one year of less than perfect life expectancy as less than 1. QALYs can therefore provide an indication of the benefits gained from a variety of medical procedures in terms of quality and life and survival for the patient. £500,000 has been allocated to support a pilot to confirm cost effectiveness of the new pathway.

The publication of NICE Guidance on “Chest pain of recent onset: assessment and diagnosis of recent onset chest pain and discomfort of suspected cardiac origin” (2010) can be expected to change how these patients are managed and will shift the standard investigation from exercise ECG testing to cardiac imaging. The exercise ECG is no longer recommended to diagnose or exclude stable angina in patients without known coronary artery disease.

Instead, the likelihood of coronary artery disease will be estimated from a table taking into account the clinical assessment and the 12-lead ECG. Further diagnostic testing is then recommended as follows:

- If the estimated likelihood of CAD is 61-90%, offer invasive coronary angiography as the first line investigation if appropriate
- If the estimated likelihood of CAD is 30-60%, offer functional imaging as the first line diagnostic investigation
- If the estimated likelihood of CAD is 10-29%, offer CT calcium scoring as the first line diagnostic investigation

Most hospitals and cardiac networks in the UK have sufficient capacity for coronary angiography for those at higher risk. However, implementation of this NICE guideline will result in a significantly increased requirement for functional imaging (in place of exercise ECG testing) and, for many centres, the need for of a new cardiac CT service.

2.4.2 STABLE CHEST PAIN

Myocardial perfusion scintigraphy (MPS) is an established technique for the diagnosis of Coronary Artery Disease and for assessing prognosis in patients with known disease. (Underwood et al 2007). MPS involves the intravenous injection of small amounts of a radioactive tracer to evaluate perfusion of living cardiac muscle via the coronary arteries after stress and at rest. It is a non-invasive procedure which provides more detailed information about coronary function than stress ECG and coronary angiography (CA). NICE recommends that routine use of CA without prior non-invasive testing is not advisable, because of its high cost and associated mortality and morbidity.

In 2003, the National Institute for Health and Clinical Excellence (NICE) appraised Myocardial perfusion scintigraphy (MPS) in patients with angina and myocardial infarction and concluded that MPS is clinically effective and cost-effective in patients presenting with stable chest pain and an intermediate likelihood of CAD. (National Institute for Clinical Excellence Technology Appraisal Guideline:73, 2003).

In the recently published NICE Clinical Guideline 95, Chest Pain of Recent Onset (2010), which supersedes TAG:73, it is recommended that the following non-invasive functional imaging options should be used for myocardial ischaemia:

- myocardial perfusion scintigraphy with single photon emission computed tomography (MPS with SPECT) or
- stress echocardiography or
- first-pass contrast-enhanced magnetic resonance (MR) perfusion or
- MR imaging for stress-induced wall motion abnormalities.

It is recommended that the choice of imaging modality should take account of locally available technology and expertise, the person and their preferences, and any contraindications when deciding on the imaging method.

The original technology appraisal (2003) reported a target provision of 4000 SPECT tests per million population per year and it was estimated that this would require 73 additional gamma cameras in England and Wales, at a capital cost of around £18 million. This was based on providing 2000 scans per annum per gamma camera, and a unit cost of £250,000 per camera. There is still a significant shortfall in availability.

2.5: Impact of advanced imaging technologies on stroke and transient ischemic attacks (TIA)

2.5.1 STROKE

A stroke occurs when the blood supply to the brain is interrupted by a blood clot or a bleed from a blood vessel in or around the brain. Stroke is the third biggest killer in the UK (Dr Foster, 2004) after cancer and heart disease, leading to more than 67,000 deaths a year. It is the UK's leading cause of disability with more than 900,000 people living with the effects of stroke, half of whom are dependent on others for everyday living (National Audit Office, 2005).

There are a number of important NHS targets relating to the diagnosis and management of stroke in the NHS Operating Framework for 2010/11:

Relating to Tier 1 Vital Signs:

- Implementation of the Stroke Strategy, which is intended provides a quality framework to secure improvements to stroke services
- Ensuring that more patients, for whom there is potential benefit, have a brain scan within 1 hour of admission and a carotid intervention, echocardiography and ECG within 48 hours.
- Accelerating the investigation and treatment of transient ischemic attacks (TIA).
- All patients with suspected acute stroke are immediately transferred by ambulance to a receiving hospital providing hyper-acute stroke services (where a stroke triage system, expert clinical assessment, timely imaging and the ability to deliver intravenous thrombolysis treatment are available throughout the 24 hour period).

Relating to Tier 2 Vital Signs:

- Post stroke death and dependency rates

National Service Framework for Coronary Heart Disease Indicators:

N.B. Emphasised the importance of early diagnosis.

- Rate of cardiovascular events in people with a prior diagnosis of CHD, PVD, TIA or occlusive stroke.

The NHS target to give a stroke patient a CT scan within 48 hours of admission and to treat patients within a specialist stroke unit was based on an observation that the minority of hospitals that were doing this pre 2004 were achieving significantly better in hospital death rates (Dr. Foster, 2004). Advanced imaging technologies such as (Computed Tomography) CT, (Magnetic Resonance Imaging) MRI scans and Positron Emission Tomography (PET) contribute to effective diagnosis and treatment of the patient by:

- rapid diagnosis of stroke and its cause;
- defining the extent of brain damage and the prognosis;
- guiding the selection of interventions to rehabilitate the patient; and
- evaluating the impact of interventions to rehabilitate the patient.

Wardlaw et al (2004) determined the effect of CT scanning in the stroke pathway on functional outcome, cost, length of stay and five year quality of life. For 1000 patients aged 70 to 74 years, the following results were shown on the next page.

The authors (Wardlow et al, 2004) concluded that immediate CT scanning was the most cost effective strategy, *presenting the lowest average cost per QALY*, and that, for most patients, increasing independent survival by correct early diagnosis and appropriate treatment reduced costs of and increased quality of life years.

In November 2008, the Centre for Evidence Based Purchasing (CEP) published an evidence review on CT perfusion imaging in the management of stroke and transient ischemic attack. They concluded that CT perfusion imaging shows significant potential in the assessment of patients with symptoms of acute stroke:

- It can be performed immediately following a non enhanced CT scan, so there are negligible treatment delays;
- It has higher sensitivity to detect ischemia, reducing the need for subsequent referrals for MRI;

Table 3: Effect of CT Scanning Protocol on Cost and Quality

Strategy	Cost	QALY
Scan within 48 hours	£10,279,728	1,982.3
Scan immediately	£9,993,676	1,982.4
Scan high risk patients immediately (on anticoagulants or with life threatening condition) and the rest within 14 days	£12,592,666	1,931.8
Scan no patients	£10,544,000	1,904.2

- It can distinguish salvageable brain tissue from infarct and could help in triaging patients for intravenous thrombolytic treatment when the time of onset of symptoms is unknown or outside the recommended time window
- CT is more readily available than MRI and has fewer contraindications

Most patients in England with suspected acute stroke are already being imaged but as a result of NICE Clinical Guideline 68 (2008) the proportion examined as a matter of urgency and the proportion undergoing MRI as well or instead of CT is targeted to increase.

2.5.2 TIA – TRANSIENT ISCHAEMIC ATTACKS

A TIA happens when the brain's blood supply is interrupted briefly. The symptoms are similar to a stroke, but temporary and usually disappear within 24 hours. Every year approximately 150,000 people in England suffer a suspected TIA, following which there is a 20% risk of a full stroke occurring within four weeks (Department of Health, National Stroke Strategy 2007). Studies show that quick treatment following a TIA can reduce the risk of stroke by 80% (Joe Korner, The Stroke Association, <http://www.apmhealthurope.com/>). There is therefore an advantage in treating TIA's as medical emergencies, although they are not widely perceived as such across the UK.

NICE recommends that patients with TIA are assessed by a specialist within 1 week of onset of symptoms and that those at risk of stroke undergo brain imaging (preferably MRI unless contraindicated, when CT can be used). In addition they recommend that candidates for carotid endarterectomy should have carotid imaging within 1 week of onset of symptoms.

The Department of Health Stroke Strategy Imaging Guide (2008) and the NICE Stroke Guideline (2008) recommend MRI for patients having had a transient ischemic attack. The guide states that many of the patients with TIA are not currently being imaged and of those that are, few are imaged with any urgency. Both the number of imaging examinations (mainly MRI) and the urgent component will rise very substantially. The same applies to carotid imaging.

3: The advanced imaging horizon and benefits to the NHS

Recent developments in imaging technologies and evidence of their potential impact have been included in previous sections. This section describes a small but significant selection of further examples of innovations in advanced imaging technology and the benefits that can be expected from NHS adoption.

3.1: Digital Mammography

Conventional mammography systems use x-ray film, which has to be processed and developed like normal photographic film. The new digital systems display the image of the breast directly onto a computer screen. The radiologist is able to zoom in, adjust the contrast and manipulate the image in order to have the very best chance of detecting tumours. In many cancer cases the changes in breast tissue are often very subtle, and detecting cancer is sometimes akin to detecting a needle in a haystack.

Digital mammography has several significant advantages:

- **Detects cancer earlier.** A large scale Norwegian study in 2004 (Skaane) showed that in a group of 500,000 women, about 1500 additional cancers would potentially be detected earlier using digital mammography than would be detected using x-ray film. Early detection offers the opportunity to treat cancers earlier in their development with less aggressive treatments. Early detection can mean that the cancer is less likely to have spread to lymph nodes, and can make the difference between keeping and losing a breast.
- **Digital mammography considered better for women with dense breasts.** A study of over 49,500 women in the US comparing digital mammography with film based systems showed digital mammography was significantly better in screening women who fit any of three categories: women with dense breasts, women under 50 and pre- or peri-menopausal women of any age (defined as women who had a last menstrual period within 12 months of their mammograms) (Pisano et al, 2005)
- **Lower dose from x-rays.** Digital mammography can reduce x-ray exposure by 25% compared with film based systems (Hermann et al 2002). Although there are huge benefits from regular mammography, there is an extremely small radiation risk associated with the examination. It is important that this risk is minimized.
- **Fewer recalls because of technical failures:** With digital mammography the radiographer can immediately see the image of the breast directly on the screen. This means if the image is not quite good enough – for example the woman has moved during the process – the procedure can be repeated straight away. With a conventional mammography system the x-ray film needs to be developed before any faults are detected. Recalls can be a very stressful time for the patient and her family.
- **Quicker, more patient-centred examination.** Because the image is displayed directly on the screen, the radiographer can immediately check the quality and can devote more time to the patient rather than processing film. Examination times are quicker (average 7 minutes with digital, 12 minutes with film), making it less stressful for the patient.
- **Breast history is more easily monitored.** Because the system creates an electronic image rather than a hard copy, the problem of lost or mislaid films is eliminated. This makes it easier for the radiologist to study all a woman's mammograms taken over time and detect any changes.

- **Easier sharing of mammogram images between specialists.** Digital mammograms are stored as an electronic image. This means they can be quickly sent to other centres for a second opinion, and shared much more easily by the multidisciplinary teams involved in breast cancer (typically a surgeon, radiologist and a pathologist). Digital images also will allow “telemammography” whereby the mammogram can be examined by a radiologist in another centre. This will be particularly beneficial to rural hospitals, or where shortage of radiologists is a problem, and offers the promise of faster diagnosis. It can also facilitate dual reporting, (where two radiologists report on the same study to increase QA and detection rates).
- **Opens the door to new, more advanced diagnostic applications.** Digital mammography also enables new diagnostic opportunities that go beyond just replacing film with digital data. It also makes possible completely new applications that are not realisable with conventional mammography:
- **Computer Aided Detection (CAD).** CAD is a software tool which analyses the digital image to “flag” areas with a high probability for malignancy. The radiologist first reviews the

image and then activates CAD. She/he then reviews the “flags” for lesions she/he may have missed. Thus CAD points to lesions that were previously overlooked, and, in combination with the radiologist, enhances the sensitivity of the review. This can help detect cancers at an earlier stage. With digital detection, the image is available for CAD instantly. While CAD can also be used with film based systems, the film image must first be digitised, adding an additional step to the process.

- **Tomosynthesis.** In certain cases a possible limitation of mammography is that it is a 2-dimensional technique and that several structures in the breast can overlap in the projection image. This can cause a combination of some structures in the breast to look like a malignancy or, worse, a genuine malignancy to be hidden by other structures, hence reducing sensitivity and specificity (causing false cancer diagnosis and missed cancers). Tomosynthesis allows radiologists to get 3-dimensional images of the breast and is expected to further improve sensitivity and specificity of breast cancer detection.

3.2: Cardiovascular MRI

Cardiac (or cardiovascular) MRI, known as CMR, uses a suitable MRI scanner to image the heart. It is a radiation-free, non-invasive technique. There are multiple different CMR techniques that can be performed upon one acquired scan for different indications. Less than half of all CMR scans are for coronary artery disease, for example. Most (90%) of patients will be outpatients, but it is also valuable for inpatients, especially when planning complex interventions.

There are some contraindications to CMR, most commonly pacemakers, implantable defibrillators or intraocular metallic objects. Problems such as arrhythmias have largely been overcome by technical advances allowing more rapid image acquisition. Most newer stents and surgically replaced cardiac valves are designed to be safe at 1.5 and 3T field strengths. Severe renal failure (GFR<30mls/min) is, however, a relative contraindication to the use of MR contrast agents. CMR is an alternative to other tests in many circumstances when initial tests do not give all the answers, and it is the gold standard in other circumstances. These include congenital heart disease from infancy to adulthood (although there remains a place for angiography, particularly for pressures and vascular resistance assessment), and other conditions such as cardiomyopathy, iron overload, myocarditis, and heart scarring. It provides added value that no other test can easily achieve. CMR can have a significant impact upon clinical decision making, patient management and prognostication. Within one scan any of the following can be performed:

- **Structure and Function:** CMR is an excellent test for cardiac function and structure, particularly where echo leaves questions unanswered. It is more accurate than echocardiography for documenting ventricular function (Chan, 2006). CMR is especially good at imaging the right ventricle and great vessels. Echo is better for diastolic dysfunction and valve morphology, so the two tests are complementary.

- **Blood flow:** Blood flow and velocity can be measured in the heart and large arteries (limited in the coronary arteries). This is particularly important in investigating congenital heart disease.
- **Infarction and Hibernation:** Using MR contrast agent the extent of heart scarring can be detected and it can be shown how heart muscle will improve with revascularisation (viability versus hibernation).
- **Perfusion:** CMR is a growing test for perfusion and ischemia testing. It has similar accuracy to nuclear cardiology and carries prognostic information but has advantages for some groups such as the young (no ionising radiation), and patients with known coronary artery disease (added value). Dobutamine (stress) CMR can also be performed, which is particularly useful when echo windows are poor, an advantage that is reduced if echocardiographic contrast is used.
- **Other:** Coronary anomalies are well demonstrated by CMR techniques but all other anatomical coronary indications are better done by CT or invasive angiography.

A well thought-out evidenced imaging strategy may reduce the need for inappropriate imaging and revascularisation procedures leading to more targeted use of resources for patients and better outcomes.

3.3: Developments in Interventional Radiology

In 2009 the National Imaging Board produced a report on the impact of interventional radiology (IR) on improving quality and outcomes for patients.

Interventional radiology is a minimally invasive alternative to open surgery or medical intervention that relies on radiological image guidance e.g. Fluoroscopy, CT or MRI. It states that there is extensive literature demonstrating that appropriate, timely radiology intervention enhances patient safety, patient experience and patient outcomes with proven efficiencies to the service. It lists a number of examples including:

- Magnetic Resonance Angiography to rapidly detect peripheral vascular disease and provide endovascular treatment. Delayed diagnosis and treatment would result in surgery or amputation.
- Emergency CT and angiography to locate the site of a colorectal bleed allowed rapid occlusion of the artery in question, avoiding open surgery and a long stay in hospital

In addition to these examples, imaging is vital in the interventional setting to support neurological and vascular treatments such as:

- Brain aneurism coiling – Platinum coils are placed into the aneurism to block blood flow using an image guided procedure. This prevents haemorrhagic stroke.
- Brain blood vessel clot treatment – clot dissolving drugs are not always available within the recommended three hours of the patient having a stroke or sometimes patients are just not suited to intravenous drug therapy. In these instances, clot dissolving drugs can be administered directly to the site of the clot using image guidance. This allows more patients access to treatment.
- Brain vessel clot removal.
- Angioplasty to open clogged blood vessels.

The National Imaging Board report argues that increasing evidence is available to support that a comprehensive interventional radiology service is essential in an acute hospital that admits emergency patients in order to reduce avoidable death (Healthcare Commission Report 2006). Interventional radiology procedures often replace open procedures and they are generally easier for the patient because they involve no large incisions, less risk, less pain and shorter recovery times. However, lack of availability of appropriate diagnostic equipment (advanced imaging technologies) is one of several constraints to delivering an effective IR service (National Imaging Board: Cardiac Imaging. A Report from the National Imaging Board March 2010).

3.4: Other emerging technologies

The following table includes a selection of new or enhanced imaging technologies that will also result and faster and more accurate imaging and ultimately faster and more appropriate and effective treatment:

Table 4: Selection of Emerging Technologies and Their Potential Benefit

Technology	Application
Multi-channel RF systems with MRI	Faster and higher resolution images enabling use of MR as an alternative to CT and conventional angiography. This would reduce the patient’s exposure to ionising radiation.
Magnetocardiography	Measures magnetic fields produced by electrical activity – locates sources of abnormal heart rhythms to support more accurate local treatment
PET imaging	Allows measurement of absolute blood flow to heart muscle under stress and rest conditions, to determine the effects of a heart attack or myocardial infarction and identify areas of the heart that might benefit from intervention.
Body Surface Potential Mapping	60-120 electrode ECG
Nuclear Medicine D Spectrum Camera	10 fold increase in sensitivity
Coronary Calcium CT Scanning	Detects a marker of coronary artery disease
Improved CT scanning – higher resolution, faster acquisition time, and lower dose	Coronary angiograms (images of blood vessels) i.e. less invasive angiography. Scanners with higher slice and/or dual source offer examinations that permit comfortable breath holds (where appropriate) for even the most challenging patients, and can reduce dose significantly. Dynamic imaging of larger areas, such as whole brain perfusion is also now possible.
Computer aided detection in mammography film reading	Cancer detection rate as good as a double reading [Radiology 2006 241 (1) 47-53 Breast Cancer Research 2008 10: R64] 18,232

In general scanners are getting faster, more sensitive and accurate and occupy less space. This contributes to efficiency and effectiveness in the following ways:

- Increased throughput and productivity
- Faster access to appropriate treatment
- Increased diagnostic accuracy
- Reduction in avoidable diagnostic and interventional procedures
- Reduction in medication costs
- Reduction in avoidable admissions
- Early intervention increases survival and improves quality of life in a number of important disease areas e.g. breast and colorectal cancer.

Conclusion

Delivering annual savings of up to £3.5 billion through staff productivity will involve substantial service transformation across the NHS. This will include reducing unnecessary admissions to hospitals, eliminating unnecessary steps in clinical processes and minimising error and waste. It makes intuitive sense that earlier accurate identification and treatment of diseases would contribute to all of these things.

There is growing body of evidence that advanced imaging technologies are relatively cost effective and a reliable precursor to leaner and more effective care pathways. Much of this evidence has been generated in the US in response to challenges raised by insurers about escalating costs. The evidence has been robust enough to date to defend unrestricted patient access to these tests.

Experience in the US case confirms that it is unlikely that the increasing cost of advanced imaging technologies is one of the main drivers for the increase in overall healthcare expenditure (Beinfeld and Gazell, 2005). If the finding that for every 1 dollar spent results in 3 dollars saving is transferable across different healthcare markets, this would provide a major enabler for NHS reform.

The evidence base is still relatively small, so it's essential for the NHS to develop more advanced ways of measuring return on sizeable capital investment that include the impact on downstream costs. This is an endeavour that would lend itself to increased partnership between the NHS and healthcare industries. Whilst there are some limitations, the current evidence base suggests that to decelerate innovation and expansion in advanced medical imaging would be ill advised.

In addition to improving productivity, advanced imaging technologies reduce the cost burden of diseases, prolong life expectancy and improve quality of life. Advanced imaging technologies therefore have a significant contribution to make in delivering key NHS targets including:

- **Financial balance**
 - reducing unit costs and variations
 - reducing the number of acute beds
- **General operational performance targets**
- **Cancer targets**
 - A critical enabler to increasing focus on early interventions
- **Heart disease targets**
 - A critical enabler to increasing focus on early interventions
- **Stroke targets**
 - A critical enabler to increasing focus on early interventions

There are clear points of impact of advanced imaging technologies on NHS deliverables. However, finding the operational capital for expensive new imaging technologies remains a challenge under the current financial regime.

New innovative ways of resourcing these technologies need to be adopted. For example, managed equipment service contracts involve equipment suppliers in supplying, installing and maintaining key categories of advanced healthcare technologies. These contracts require the equipment partner to keep the equipment updated. There are financial advantages to these arrangements, including the share of operational and financial risk and VAT advantages. In spite of these advantages, uptake is slow across the NHS. It is argued that prudent investment in developments to advanced imaging technologies will result in faster, more accurate, safer and less invasive tests. It will be central to QIPP and the delivery of the NHS five year strategy, **“NHS 2010-2015 from Good to Great”**.

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Appendix 1: Guide to Imaging Technologies

MRI – Magnetic Resonance Imaging

MRI is a medical imaging technique most commonly used in radiology to visualise the structure and function of the body. MRI provides detailed images of the body in any plane. MRI provides much greater contrast between the different soft tissues of the body than computed tomography (CT) does, making it especially useful in neurological (brain), musculoskeletal, cardiovascular, and oncological (cancer) imaging. Unlike CT, it uses no ionizing radiation, but uses a powerful magnetic field to align the nuclear magnetization of (usually) hydrogen atoms in water in the body. Radiofrequency fields are used to systematically alter the alignment of this magnetization, causing the hydrogen nuclei to produce a rotating magnetic field detectable by the scanner. This signal can be manipulated by additional magnetic fields to build up enough information to construct an image of the body.

CT – Computed Tomography

Computed tomography is a medical imaging technology which takes a series of x-ray ‘slices’ through an object. A computer rebuilds these slices into a three-dimensional image using a process called tomography. CT scans are also sometimes known as CAT scans (Computer Aided Tomography).

Positron Emission Tomography (PET)

The patient to be scanned is injected with trace amounts of a short-lived positron-emitting radioisotope bound to a metabolically active molecule. Gamma rays emitted by the positron-emitting radioisotope then reflect the body’s uptake of the metabolically active molecule. A computer uses these data to construct a three dimensional image, often in conjunction with an integrated CT scan.

Ultrasound and Echocardiography

An echocardiogram employs ultrasound techniques to generate a two-dimensional image of the heart.

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